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INVESTIGATION OF AIR TRANSPORTATION TECHNOLOGY AT OHIO UNIVERSITY 1992-1993

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SUMMARY OF RESEARCH

The Joint University Program in Air Transportation Systems provides opportunities for progress by students, staff and faculty at the Avionics Engineering Center, Ohio University. During the 1992-93 year, four conference papers and two M. S. theses were produced; these are summarized in the bibliography below. The conference papers are included in their entirety, for reference.

- Interest in the satellite-based Global Positioning System (GPS) in the interferometric mode implies the need for highly accurate position and velocity estimates in real time, from multiple antennas. Such advanced applications require also an excellent knowledge of the transmitted signal's characteristics (studies of Selective Availability and methods for mitigation).

  Differential mode operations are also implicit when interferometric GPS is applied to aircraft approach operations (studies of ground station siting and performance).

  GPS hybridization with other systems is a key element in eventual sole-means navigational use of the system. Studies of combined GPS/Loran-C and GPS/IRS are supporting this future priority.

  GPS system availability is a pervasive concern, and is a complicated quantity related to required user accuracy, position and time. A comprehensive coverage model is under development.

- Although specific papers were not generated in the weather-uplink research area, this work did support a spin-off effort. Knowledge gained in the weather-uplink work is now being applied in differential GPS uplink studies supported by FAA.

- Fault detection and isolation (FDI) work continues, in direct support of GPS integrity assurance standards being developed for FAA by RTCA. Much of the past FDI work generated in the Joint University Program has been adopted as part of these national/international standards.

ANNOTATED BIBLIOGRAPHY OF 1992-93 PUBLICATIONS

1. Braasch, M. S.; Fink, A. B.; Duffus, K.: Improved Modeling of GPS Selective Availability. Proceedings of the ION National Technical Meeting, San Francisco, CA, January 20-22, 1993.

Selective Availability (SA) represents the dominant error source for stand-alone users of GPS. Even for DGPS, SA mandates the update rate required for a desired level of accuracy in realtime applications. As has been witnessed in the recent literature, the ability to model this error source is crucial to the proper evaluation of GPS-based systems. A variety of SA models have been proposed to date; however, each has its own shortcomings. Most of these models have been corrupted by additional error sources. This paper presents a comprehensive treatment of the problem. The phenomenon of SA is discussed and technique is presented whereby both clock and orbit components of SA are identifiable. Extensive SA data sets collected from Block II satellites are presented. System Identification theory then is used to derive a robust model of SA from the data. This theory also allows for the statistical analysis of SA. The stationarity of SA over time and across different satellites is analyzed and its impact on the modeling problem is discussed.

2. Braasch, S.: Realtime Mitigation of GPS SA Errors Using Loran-C. Wild Goose Association, Annual Convention and Technical Symposium, August 24-27, 1992, Birmingham, England.

3. Braasch, S.: Realtime Mitigation of GPS Selective Availability Using Loran-C. M.S. Thesis, Ohio University, Department of Electrical and Computer Engineering, Athens, OH, June 1993.

The hybrid use of Loran-C with the Global Positioning System (GPS) has been shown capable of providing a sole-means of enroute air radionavigation. By allowing pilots to fly direct to their destinations, use of this system is resulting in significant time savings and therefore fuel savings as well. However, a major error source limiting the accuracy of GPS is the intentional degradation of the GPS signal known as Selective Availability (SA). SA-induced position errors are highly correlated and far exceed all other error sources (horizontal position error: 100 meters, 95 %). Realtime mitigation of SA errors from the position solution is highly desirable. This paper discusses how that can be achieved. The stability of Loran-C signals is exploited to reduce SA errors. The theory behind this technique will be discussed and results using bench and flight data will be given.

4. Skidmore, T. A.: A GPS Coverage Model. Proceeding of the ION National Technical Meeting, Washington, DC, June 29 - July 1, 1992.

This paper summarizes the results of several case studies using the Global Positioning System coverage model developed by Ohio University. Presented are results pertaining to outage area, outage dynamics, and availability. Input parameters to the model include the satellite orbit data, service area of interest, geometry requirements, and horizon and antenna mask angles. It is shown for precision-landing Category I requirements that the planned GPS

21 Primary Satellite Constellation produces significant outage area and unavailability. It is also shown that a decrease in the user equivalent range error dramatically decreases outage area and improves the service availability.

5. Waid, J. D.: Ground Station Siting Consideration for DGPS. Proceedings of the ION National Technical Meeting, San Francisco, CA, January 20-22, 1993.

6. Waid, J. D.: Development of an Interferometric Differential Global Positioning System Ground Reference Station. M.S. Thesis, Ohio University, Department of Electrical and Computer Engineering, Athens, OH, March 1992.

Aircraft guidance and positioning in the final approach and landing phases of flight requires a high degree of accuracy. The Global Positioning System operating in differential mode (DGPS) is being considered for this application. Prior to implementation, all sources of error must be considered. Multipath has been shown to be the dominant source of error for DGPS and theoretical studies have verified that multipath is particularly severe within the final approach and landing regions. Because of aircraft dynamics, the ground station segment of DGPS is the part of the system where multipath can most effectively be reduced. Ground station siting will be a key element in reducing multipath errors for a DGPS system. This situation can also be improved by using P-code or narrow correlator C/A-code receivers along with a multipath rejecting antenna. This paper presents a study of GPS multipath errors for a stationary DGPS ground station. A discussion of GPS multipath error characteristics will be presented along with some actual multipath data. The data was collected for different ground station siting configurations using P-code, standard C/A-code and narrow correlator C/A-code receiver architectures and two separate antenna constructions.